"Development of Street Railway Systems in Washington, D. C."

V. H. Gray - April 23, 1937

Initiation Thesis for TAU BETA PI FRATERNITY

Maryland Beta Chapter

## SUMMARY

In tracing the development of street railway systems in Washington, D. C., it was deemed advisable to follow a chronological sequence of events during the earlier phases of the subject, but, following the adoption of electric power, the development was divided into three branches treated more or less separately and concluded with a presentation of probable trends in the future. The first phase, that of EARLY HISTORY, gives a glimpse of transportation conditions existing from 1800 until the first street railroad company was incorporated. Then, under the heading HORSE CARS, is pictured the railway facilities that were in existence before the advent of mechanical motive power. Following this is explained the operation of the picturesque CABLE CARS, along with some interesting history in their connection. In the struggle to find the best type of motive power, several interesting and ingenious devices were developed, some of which are presented under UNSUCCESSFUL EXPERIMENTS. At this stage subsequent development is divided into these main headings: COMPANY DEVELOPMENT, TRACK DEVELOPMENT, CAR DEVELOPMENT, and FUTURE. The first of these topics deals with the various companies, their mergers, and congressional assistance. To illustrate the development of the tracks, an underground conduit system is traced through its installation. Data on street car types down through the years, and a hint as to future trends complete the subject.

Throughout the paper there has been purposely omitted any reference to costs or monetary affairs whatsoever. This is to avoid complicating the subject unduly, and is also due to the justifiable reluctance of the Capital Transit Company at having their unit costs unofficially interpreted.

The author also wants to express his appreciation of the help that he received from the employees of the Capital Transit Company, who very generously offered their time and assistance in furnishing this material.

DEVELOPMENT OF STREET RAILWAY SYSTEMS IN WASHINGTON, D. C.

EARLY HISTORY

The first attempt at any organized, commercial transportation system in Washington was in 1800, when a two-horse stage coach line was put into operation between William Tunnicliff's tavern at 1'st and A, N.E. and Georgetown at M Street and Wisconsin Avenue. These coaches were scheduled to make two round trips a day, which in those days was a notable achievement. It is to be remembered that Pennslyvannia Avenue, down which the coaches plied, then more nearly resembled a muddy corn field than a street. However, the line failed as it made no profit. For the next thirty years street passenger service was confined to swarms of hacks, individually owned and unorganized. The drivers of these hacks were often unscrupulous and extortionate in price charging. Such conditions gave rise to considerable reproach, and after a time(1830) some Omnibus lines sprung up. The first was from Georgetown to the Navy Yard and later extended up to 7'th and L, N.W. These lines had a 12½¢ fare and consisted of large stage coaches that were scarcely better than the hacks. There were several competing lines, much overcrowding, and even racing for passengers and blocking each other off the road. Congress, in 1850, passed an ordinance prohibiting such conduct.

In 1858 a group of New York capitalists with a few Washington interests, applied at Congress for a charter to operate a street railway company in Washington. They failed to obtain it. However, on May 17, 1862, Congress incorporated the Washington and Georgetown Railroad Co.---the first street railway company in Washington. Accordingly, on October 2, 1862, the first street car operated in Washington pulled out of the Navy Yard on Washington and Georgetown tracks and headed, via the Capital, to Georgetown. This company also laid tracks along Boundary Street, now Florida Avenue.

## HORSE CARS

The first horse cars were very small and light, had side seats with a center aisle running the length of the car. Their weight can be deduced from the fact that one ran over a man's ankle without permanently injuring it. At first the cars were equipped with a tongue or pole to which the horses were harnessed, but they were discarded in 1872 as they were practically useless. This illustrates an unthinking adherence to precedent, as tongues had always before been used to turn the front wheels, and were obviously not needed for that purpose with rails for the wheels to follow.

These cars were unheated and became very cold in the winter. To furnish warmth for the feet the center aisle was bedded with straw, into which passengers carried mud and moisture, and which they used as a cuspidor.

These first cars were pulled by two horses, but to meet the competition of the "Chariot Line" and the "Herdic" phaeton company, they were replaced by faster, one horse, "box" cars--so called because of a box for the fare deposits. The Chariot and Herdic lines were light, fast phaetons which ran on 3¢ fares, and could drive up under porches during rainy weather. Congress prohibited one-horse cars in 1892.

All horse cars had an open front platform where the driver rode and was exposed to all weather. Agitation to enclose the driver was defeated on the ground that the front window would become coated with ice and obstruct the driver's vision, which was necessary to be unimpaired at all times to safely handle the car through the fast traffic. The horses had bells on their harness which would jingle and warn of their approach. This practice was discontinued at the complaint of one commissioner who did not like it.

Congress, in the Act of 1878, required that the street railways maintain a suitable pavement between the rails and for a distance of two feet on either side of the outer rail. The tendency at first was to pave

the streets with cobblestones so that the horses could get more traction, but in 1889 the commissioners prohibited the use of cobblestones for street paving, and since then the paving has been either of wooden blocks, asphalt, vitrified brick, or other brick, such as scoria brick,which is now used to lessen vibration.

The first rails employed with the horse cars were tram rails laid on wooden ties. It was quite customary then for the drivers, when they reached the end of the line, to drive off of the rails into the street to turn around, sometimes driving around the block. Later they changed to girder rails laid on ties spaced 18" apart, gravel ballasted and paved with stone blocks.

CABLE CARS

The District Appropriation Act of 1889 required the street railway companies operating in the District of Columbia to adopt mechanical power in propelling the vehicles and to use only flat, grooved rails. Accordingly, the Washington and Georgetown Railroad Co. began installing the second type of motive power used in Washington--cables. The cable car was invented in San Fransisco in 1873 because animal power was not sufficient to haul cars up the steep hills. They were complicated and expensive, but they still persist in San Fransisco and Seattle as it is the only system independent of wheel-rail friction.

The cable which operated the cars travelled in an underground conduit, guided by pulleys and powered by a central power plant. When the operator wanted to go foreward he would cause the grip, which depended from the car and enclosed the cable, to slowly grab the cable and thus pull the car.

In Washington,cables operated along 7'th Street,14'th Street, and Pennsylvania Avenue under the Washington and Georgetown Railroad Co. and the Columbia Railroad Co. The power houses were located at 7'th and P, S.W., and at 14'th and E,N.W.

"The cable system represents to my mind an engineering achievement as great as that of the development of the Electric Railway"--J. H. Hanna President, Capital Transit Co. Mr. Hanna did not say that because of the cable system being in basic idea anything outstanding, but it was a wonder to his mind how the engineers of that day could ever keep such an intricate system working regularly on schedule. It is a tribute to those engineers that they did succeed in maintaining service in spite of the fact that they had to keep 20 miles of steel cable running smoothly over the pulleys, with numerous cars starting and stopping, kinks and stray strands developing, grips becoming jerky and the cable breaking in two, stranding from one to two dozen cars. The system was tried severely when the Grand Army of the Republic convened and broke all previous records before and for ten years after, for passenger volume. The gripman had all that he could handle in collecting fares and at the same time manually operating the grip so that an overloaded car could start without a jerk. An interesting occurence that took place infrequently was when a loose strand would wrap around the grip and not release. The sight of a car tearing down the street at 10 miles an hour unable to be stopped was terrifying in the least. The gripman would have to jump off and run ahead to the first teleplone to have the power shut off until it could be fixed.

The power for the cables was furnished by a stationary, reciprocating, horizontal Carliss type engine which was geared by a roomfull of large spur gears to deliver power to several cables, which wound over many friction pulleys and out under the street for its circuitous route. The cable conduit was equipped with carrier pulleys every 31 feet on straight track and guard pulleys on every yoke($4\frac{1}{2}$') on curves.

With cable power, the cars improved ~~the~~ in interior conditions until little was to be desired. Also rails were adopted which had a side groove for the wheel flange to run in.

UNSUCCESSFUL EXPERIMENTS

The District Appropriation Act of 1889 which required a mechanical substitute for the horse and at the same time prohibited the use of an overhead trolley wire within the fire limits (bounded generally by Florida Avenue on the North), gave rise to several interesting devices for street car propulsion. During 1892 & 1893 there was considerable experimentation with storage battery cars. They were unsuccessful as they were too heavy and costly. Compressed air cars were tried and found unreliable. An electric system was tried which had contact plates on the ground between the rails and found unreliable. The trouble was that an automatic deadener which was supposed to cut off the current before and after the car did not always work so well and neighbors complained of their horses straying onto the track and being electrocuted. A system similar to this one had, instead, a series of magnets, which were supposed to be magnetized at the right time and attract the car. It was very unwieldy and complicated. Steam motor cars were also discarded.

Perhaps the most interesting and novel device was one tried on 7'th Street north of Florida Avenue about 1890. It consisted of two parallel tubes, six or eight inches in diameter installed in AN underground conduit and revolved against a set of staggered friction wheels attached to and depending from the car, which it impelled on the principle of a screw. The rotary motion was imparted to the tubes by small engines 500 feet apart. What was most surprising about this idea was the way in which it failed. The exaust air from the engines absorbed so much heat from the moisture of the atmosphere that the ice so generated clogged the gearing of the wheels of the engines by which the tubes were turned, and was an insuperable obstacle to the efficient operation of the device.

COMPANY DEVELOPMENT

At this point in the development a brief consideration of the legal activities of the companies is necessary. After the incorporation of the Washington and Georgetown Railroad Co. in 1862, and up unto 1890, Congress incorporated scores of individual Railway Companies. Each of these built their own tracks, operated their own routes, charged their own fares, and had complicated transfer systems. These companies, including the Metropolitan Railroad Co. which was the second street railway company in Washington, incorporated in 1864, and a pioneer in all developments, all sought aid to meet the enormous cost of electrifying their lines. Consequently, to make transfers easier and pool resources a company called the Washington Traction and Electric Co. tried to consolidate a number of lines. This company went into the hands of the receivers, but illustrated the need for such a merger. Then, by act of Congress June 5, 1900 the Washington and Great Falls Electric Railway Co. was authorized to acquire the stock of the old Washington Traction and Electric Co., which it did in 1902 and called the company the Washington Railway and Electric Co., which existed until 1933.

The companies merged into the Washington Railway and Electric Co. are: Washington and Great Falls Electric Railway Co., the Metropolitan Railway Co., the Union Railway Co.,the Brightwood and Silver Springs Railway Co., the Columbia Railway Co., the Anacostia and Potomac River Railroad Co., the Capital Railway Co., the Brightwood Railway Co., the Maryland and Washington Railway Co., The Georgetown and Tennallytown Railway Co.of the Dictrict of Columbia, The City and Suburban Railway Co. of Washington, the Columbia and Maryland Railway Co.of Maryland, AND, the Berwyn and Laurel Electric Railway Co.

In 1895 The Rock Creek Railway Co. (incorporated by Congress in 1890) acquired the stock of the Washington and Georgetown Co. and changed the name of both to the Capital Traction Company.

Congress, in 1913, passed the anti-merger law which stated that a street railway company cannot acquire the stock of another company without the authority from Congress to do so. At the same time Congress created the Public Utilities Commission consisting of three Commissioners with power to supervise and regulate every street railway company and other common carriers. In the same year a 15 mile an hour speed limit was placed over street cars operating in the business district, fenders and wheelguards were required, as also was a gong which must be sounded at the approach to any crossing or any other vehicle.

The Washington Railway and Electric Co. and the Capital Traction Co. merged on December 1, 1933 and changed the name to The Capital Transit Company. This company now owns or subsidizes all railway property and equiptment in the District. The most recent appraisal of property was made in 1931 just prior to the merger, when the two companies were still separate. The total physical property of the Washington Railway and Electric Co. was then approximately $29,600,000 and the Capital Traction Co.--$27,400,000. This valuation included property, both right of way and real estate; underground trolley track; overhead trolley track; carhouse and yard tracks; underground conduits; poles and fixtures; buildings, such as shops and carhouses and substations; bridges; passenger cars; electrical equiptment; passenger buses; service cars; electric locomotives; office, shop and road equipment, and park and resort property.

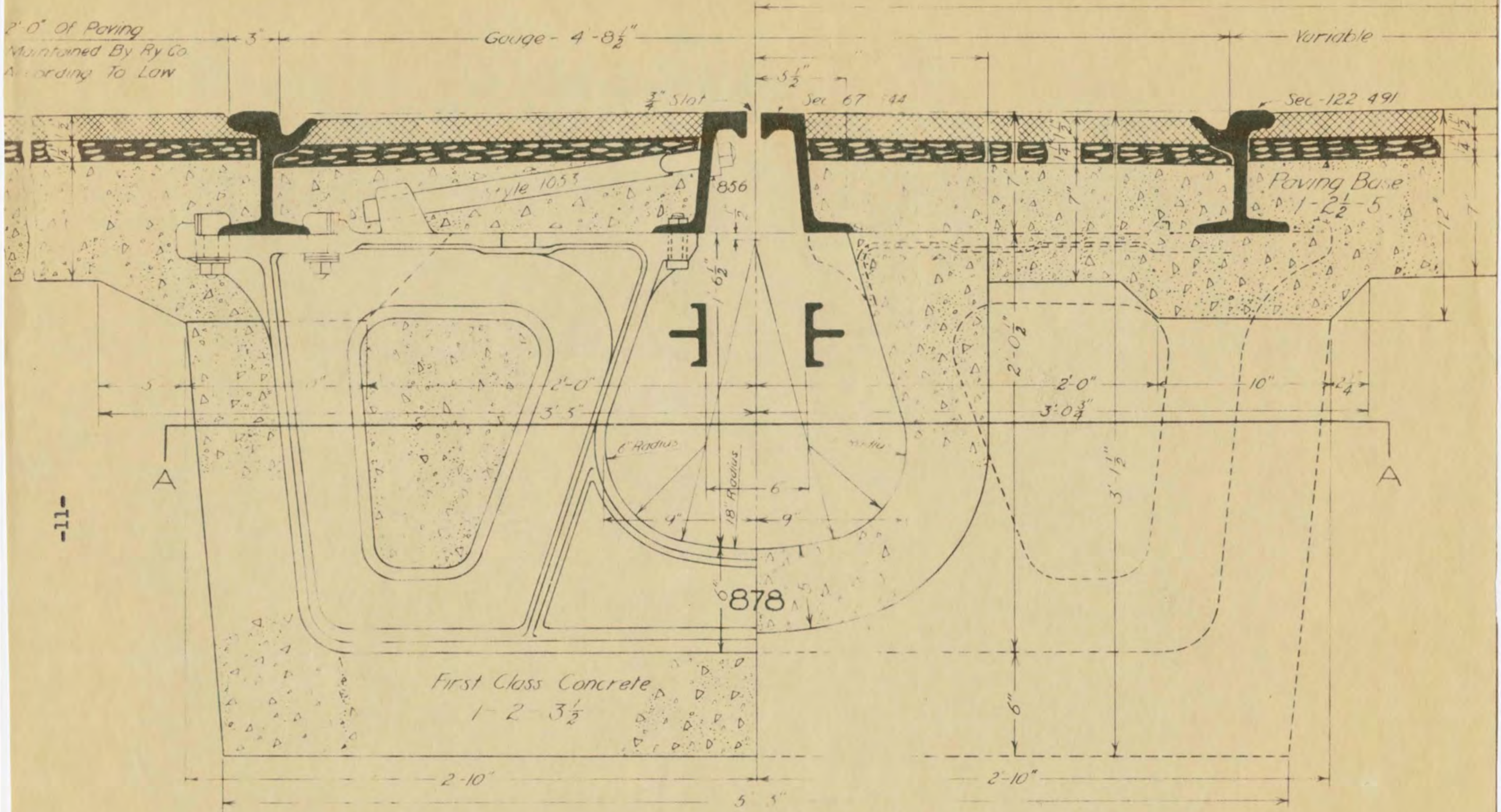
TRACK DEVELOPMENT

The underground conduit, sliding shoe system, that is now used throughout the business district of Washington was designed by Mr. A. N. Carnett, designer for the Metropolitan Railway Co., in 1896. The Rock Creek Railway Co. tried an underground set of trolley wheels called the Love System which was practical but more expensive than the sliding shoe system now used. The idea was gotten from Budapest where it had been successfully operated for

several years. This method practically supplanted all other types by the turn of the century. The overhead trolley, which was first operated in the United States by Frank L. Sprague in Richmond, Virginia, in 1888, was disqualified from the business section of Washington because the 1889 Act specified a metallic return system. This meant that the return current had to have an insulated conductor rail as well as the high potential side, and that the rails could not be used as a ground return as on the overhead trolley system.

To best illustrate the actual underground conduit track construction it is necessary to follow the steps through a typical, new installation and observe the construction. Throughout the discussion constant reference will be made to the various diagrams and cross sections that follow.

If the street has an older type construction on it, it will be necessary to remove the old tracks and sell them for scrap, in which the cost of removal generally equals the salvage value. Temporary tracks must be laid on the side of the street on wooden ties. Then the field engineer drives line and grade stakes every 25 feet, and lays an offset line. The excavation crew then excavates to the shape of the conduit tube, in which they are aided by a template of the correct shape. After this, with the aid of another template, the yoke spaces are excavated at every 4'6" (observe the yoke excavation lines on top of page 12). The cast iron yokes, as shown on page 11, are then installed, supported temporarily by stakes, and first class concrete(1-2-3½) is poured in around the yoke and set. Then the center slot rails are bolted to the yokes and the slot opening is gaged to ¾" by tightening or loosening the nut on the tie rods as shown on page 11. The wheel rails are laid on the yokes and half gaged from the slot rails, and full gaged to 4'8½" as shown. The rail clamps are then put on with shims and bolted down with two of the four bolts. Wooden tube forms are then placed and the concrete gang pours the concrete to form the tube as shown (page 11).

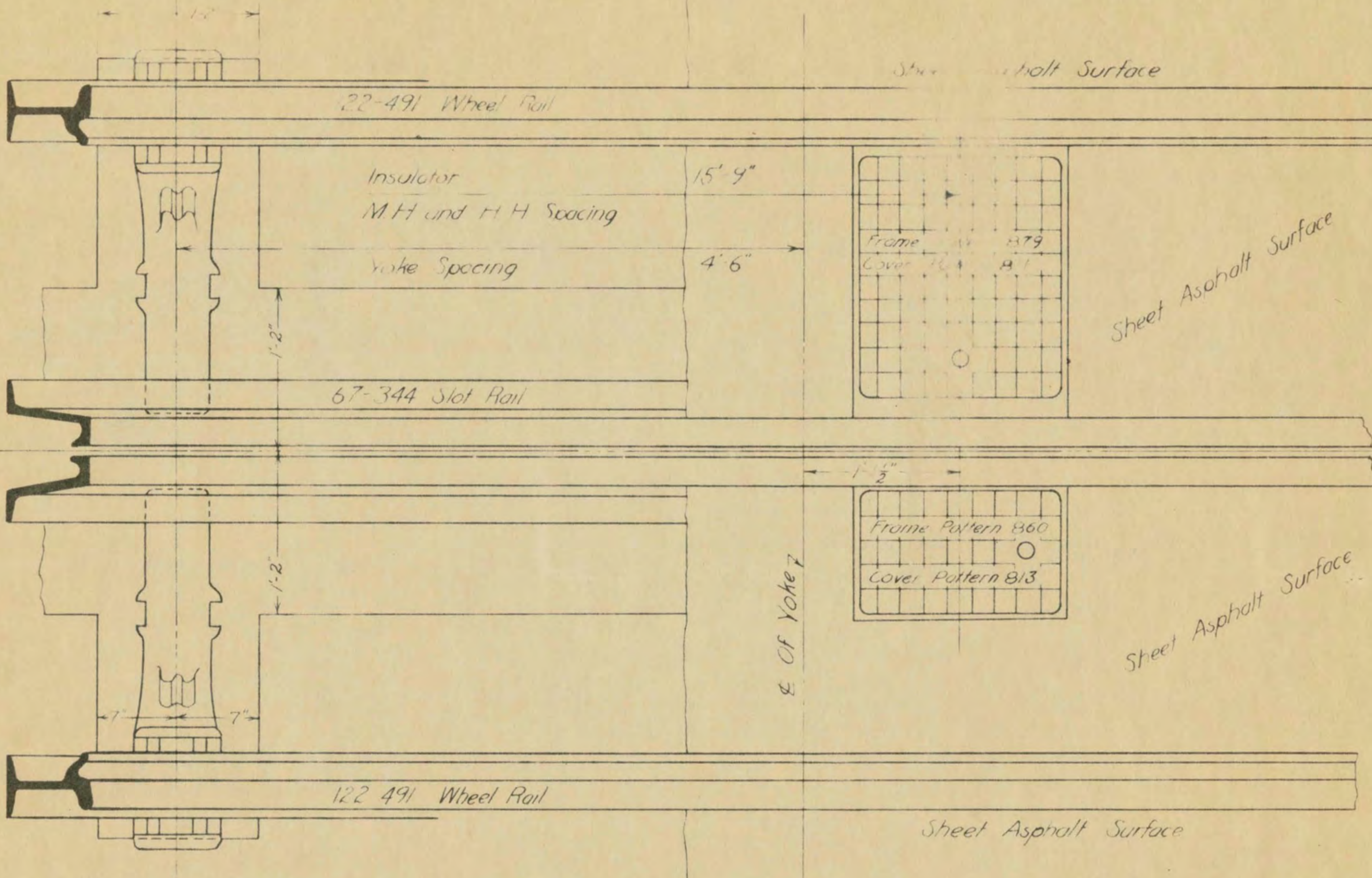



CROSS SECTIONS

SECTION AT YOKES

SECTION BETWEEN YOKES

Scale




Note -
Thermit Welded Joints

PLAN SHOWING PAVING AND M.H. AND H.H. CASTINGS

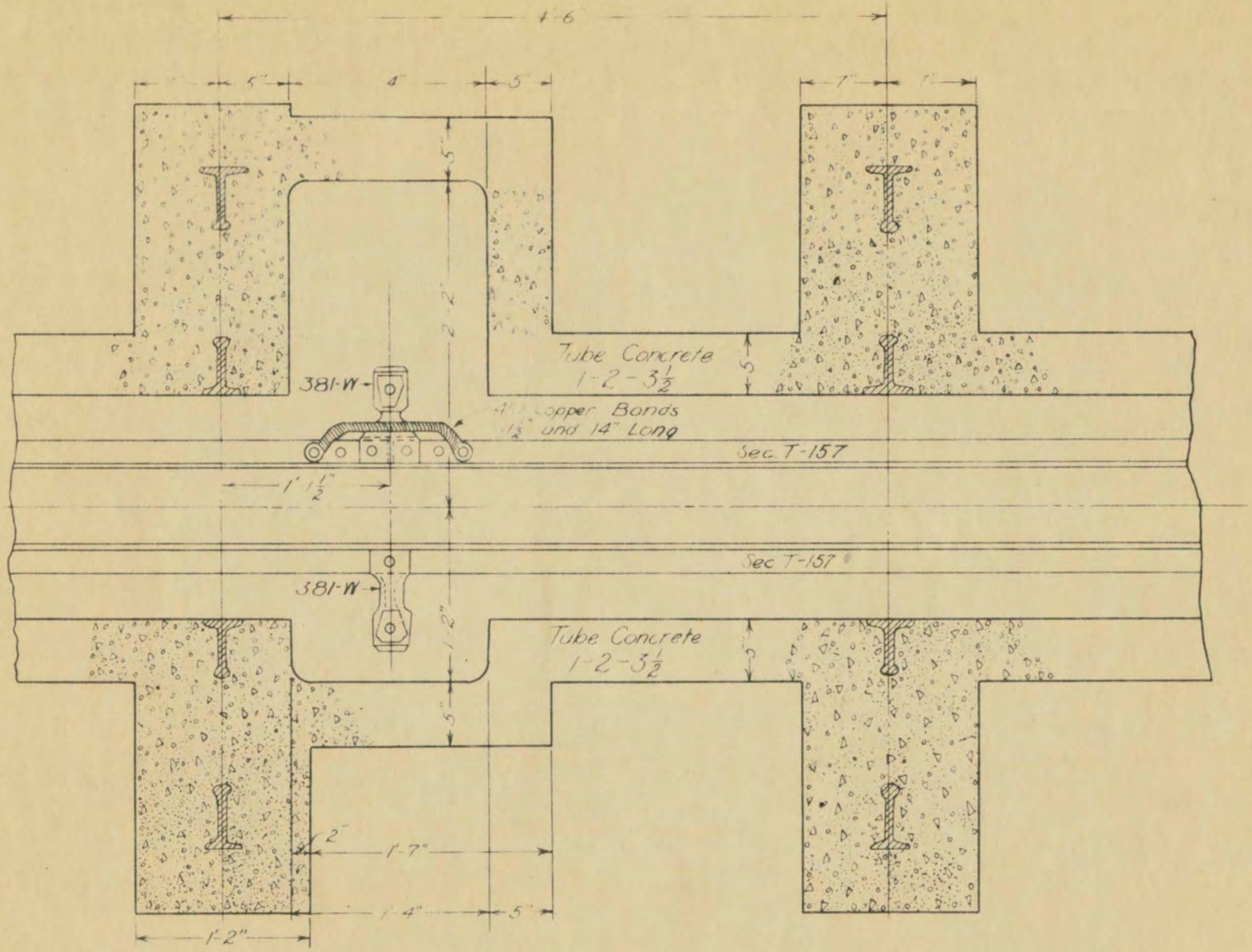
Scale 1" = 1'-0"

After the concrete has set (about two days in summer) the forms are removed, and the rails are line-and-surface checked with a transit and all bolts are placed and tightened. The manhole and handhole castings are placed and the paving base is poured for two feet on either side of the tracks with second class ($1-2\frac{1}{2}-5$) concrete 7" thick. This is covered with $2\frac{3}{4}$" of surface asphalt.

The conduit is now permanent and ready for electrification. Conductor rails are brought in through slot hatches placed every 500 feet on straight track and at the entrance to all switches and curves. The conductor rails are supported by arms from the insulators every 30 feet as shown on page 14 and page 17. At each conductor rail junction a flexible cable connector is bolted to the rails as shown on page 14.

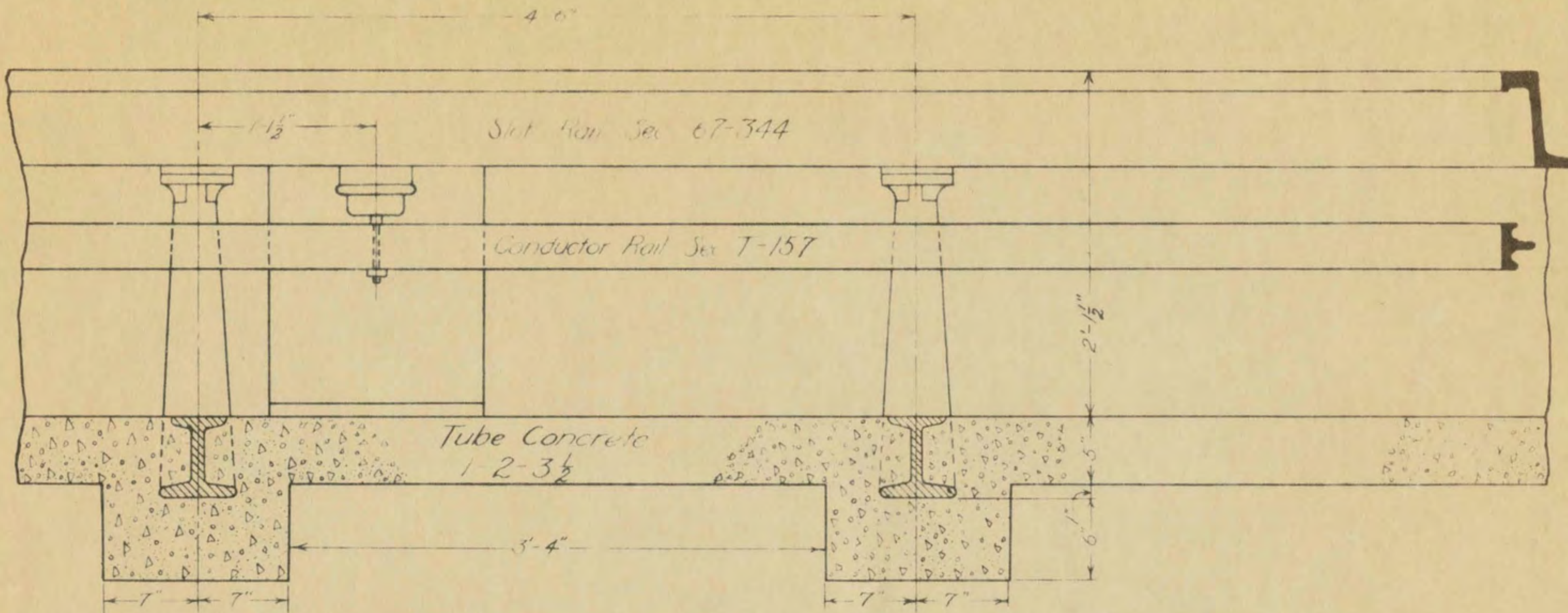
The power feeder system as diagrammed on page 16, consists of several substations dispersed throughout the system and converting the 15,000 volt alternating current from the power source to 600 volts direct current by means of rotary converters. Each car requires from 350 to 450 starting amperes and from 60 to 100 running amperes. The feeder system is designed to carry a rush hour load of 1200 amperes. Tap offs from the sub station go to the tracks at points designed to meet the power requirements. At studied areas of conjestion, for instance, there would be a power tap off every half mile or so, while in the suburbs one line could supply miles of track.

The earlier construction of conduits and yokes proved too light to support the cars as they increased so rapidly in weight. So, the period around 1907 witnessed a general reconstruction of track and installation of heavier and better designed yokes. This construction went on during regular traffic, and had to be so arranged that it did not interfere with service. Sometimes even a 30 foot wheel rail would be replaced in between street cars.




SECTION AT A-A

Scale 1"-1'0"

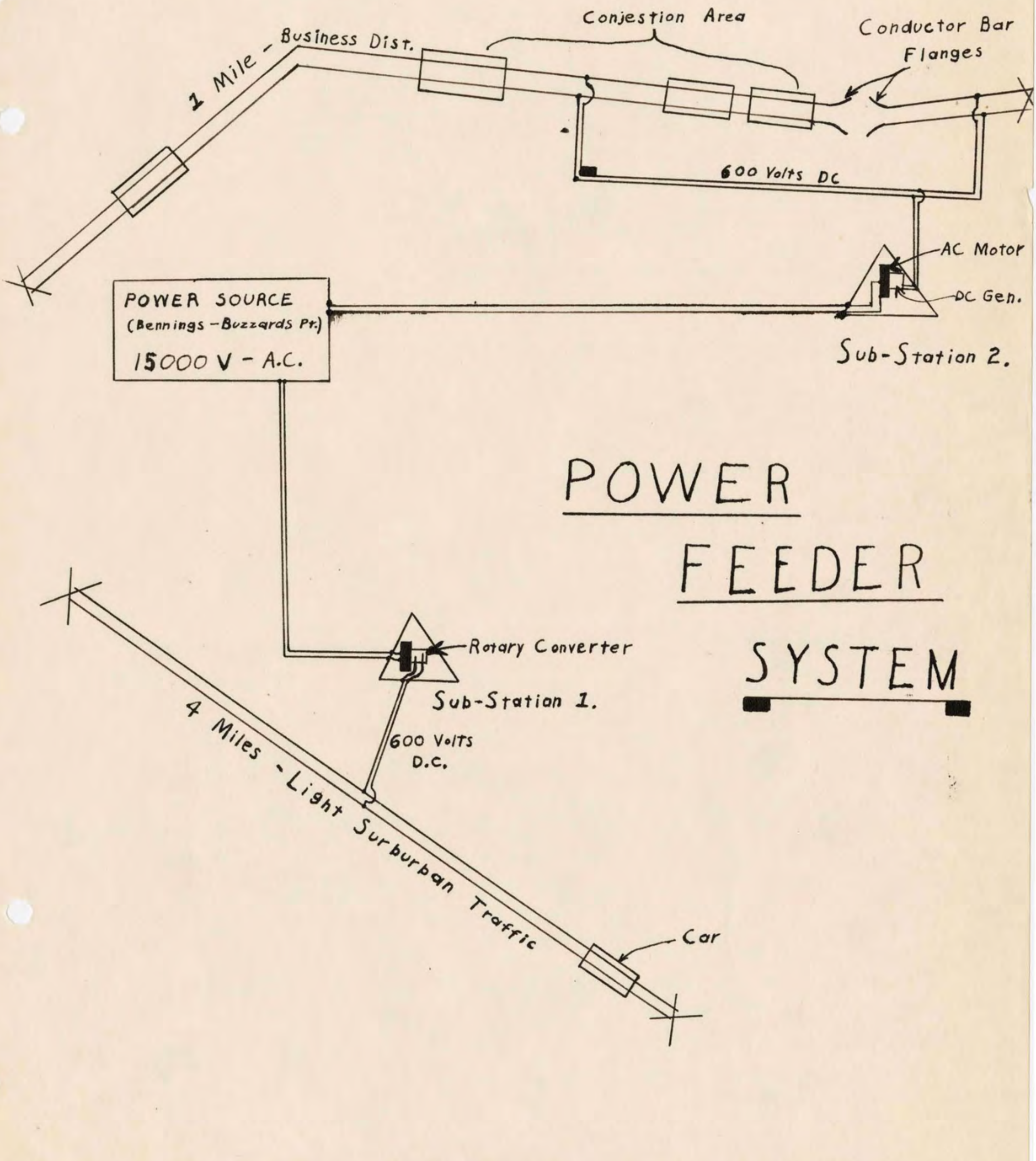


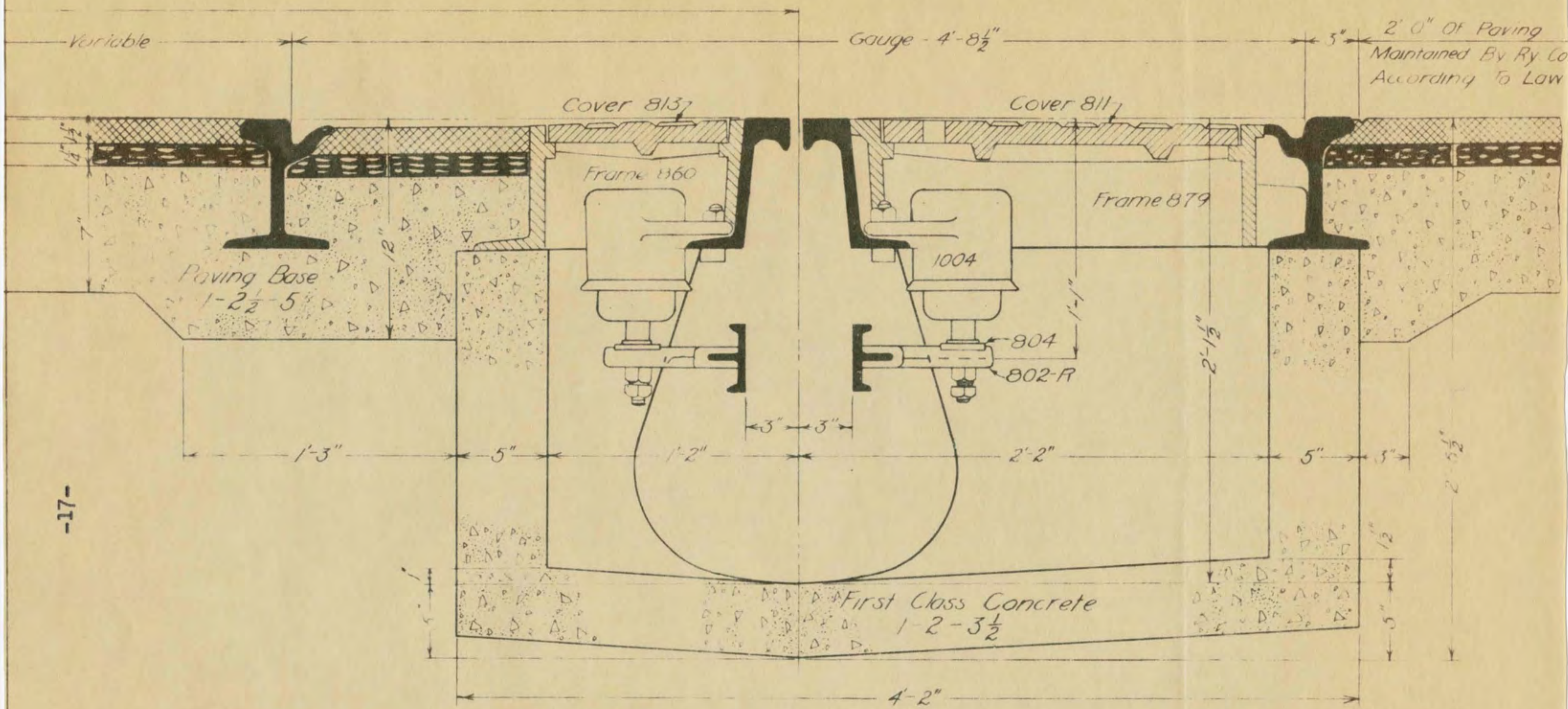

LONGITUDINAL SECTION - ℄ SLOT - STRAIGHT TRACK CONSTRUCTION

*Scale 1" = 1'-0"*

## NOTES FOR CURVE TRACK CONSTRUCTION

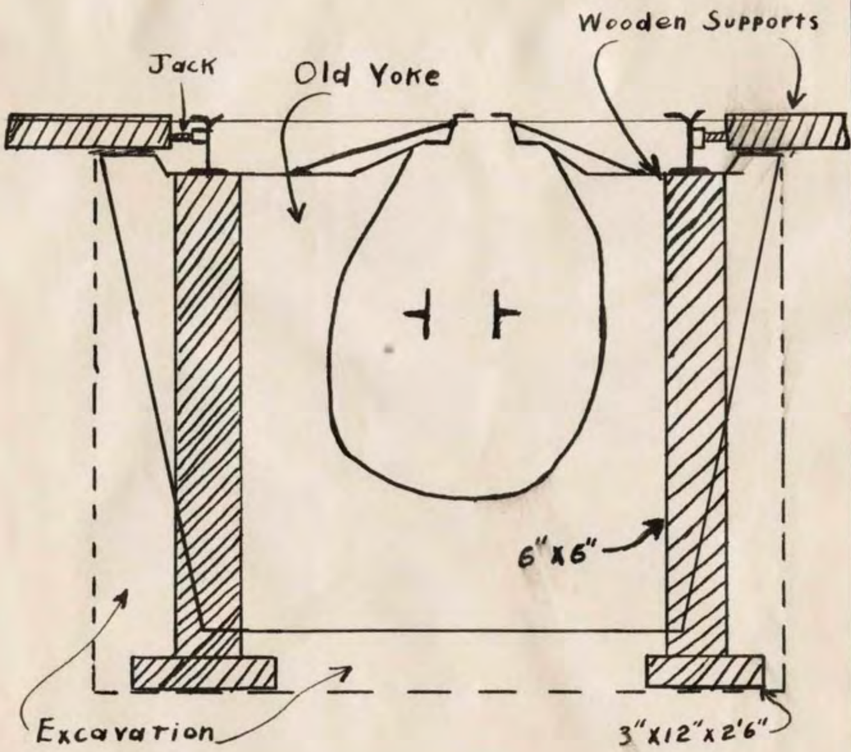
*Outer Rail - Trilby Section 122-491*
*Inner Rail - Guard Section 140-468*
*Standard Thermite Welded Joints*
*Manhole Frame 879 With ¼" Planed Off Wheel Rail Side*
*Manhole Frame 811*
*Yoke Spacing 4'-6"*
*Insulator Spacing 11'-3"*
*All Other Material Same As For Straight Track*


Conjestion Area
Conductor Bar
Flanges
1 Mile - Business Dist.
600 Volts DC
AC Motor
DC Gen.
POWER SOURCE
(Bennings - Buzzards Pt.)
15000 V - A.C.
Sub-Station 2.
POWER
FEEDER
SYSTEM
Rotary Converter
Sub-Station 1.
600 Volts
D.C.
4 Miles - Light Surburban Traffic
Car




SECTION AT MANHOLE AND HANDHOLE

Scale 1½" = 1'-0"




REPLACEMENTS

The general procedure in replacing yokes as shown above, was to swing the rails on two wooden beams, one vertical and one imbedded into the ground. Thus the rail load is taken off of the yokes and the old ones can be removed. The diagram shows the deformation occasioned by cars running over it that were heavier than the yoke was designed for.

The following photograph on page 19 shows a completed crossing at 14'th and New York Avenue that was recently installed, maintaining regular service. The picture clearly shows the manhole and handhole castings and the manganese steel inserts where two wheel rails cross, placed to take the wear.

At this corner was previously located an oddity seldom found,-that of having four parallel tracks on the same street. That was before the recent merger, when both companies operated a pair of tracks on this street.

Double track crossing double track with connecting curves in one quadrant.

CAR DEVELOPMENT

The first electric street car to operate in Washington was in a short section of track on the Eckington and Soldier's Home Line in 1888, which had a steam power plant and an overhead trolley. By 1898 the cars were almost entirely electric. The first cars had 25 foot bodies, a single truck, hand operated brakes, and two motors, each a 25HP four pole, direct current motor. The motors then, and now, are almost evenly divided between Westinghouse and General Electric.

Around 1903-5 the K controller was developed and intrapole motors installed. The K controller is the familier hand lever operated resistance box for varying speeds. Intrapole motors had extra fields in between the poles. The weight of these cars complete was near 30,000#.

Then, during 1907-8 numerous open cars were built with double trucks and two motors. During the period 1910-12 air brakes were developed with 75% braking ratio, meaning that the total braking force was $\frac{3}{4}$ of the car's weight. These cars were of the double truck type, with 37 foot bodies, 55 to 60 HP motors, some with two and some with four, weighing around 38,000#. Some of these cars, called the "maximum traction" cars had one large wheel and one small wheel with the large wheel axle carrying 60% of the load to give the

drive wheels the maximum traction.

Then, in 1912-18, the heavy double truck cars were bought, which had four motors, cross seats and the automatic circuit breaker under the car. These cars were 44 feet over all and weighed from 45-48,000#. Some of the interrurban cars are as heavy as 100,000#.

From 1918-36 there was no outstanding change in car design. 90% of the cars now in service were originally put into use before the war. The old cars were rebuilt many times and added to when improvements were imperative.

In 1936, as a result of a five year investigation, 20 new streamlined cars were built and put into operation. These cars are the very latest in street car design and deserve to be described more fully. They have an automatic accelerating control with 22 contacts, which gives a smoother take off than the old K type. These cars can move from rest to 40 miles per hour in ten seconds, a maximum acceleration of 4.5 miles/hr/sec. Ten of these were built by the J.G. Brill Co. and ten by the St. Louis Car Co. to speed production.

These cars have three independent sets of braking systems which are coordinated to give a smooth, positive stop at 150% braking ratio and a retarding rate of 8 miles/hr/sec. The brakes that take the greatest part of the load are dynamic, converting the motors into generators and absorbing the kinetic energy of the car in resistancce coils. When reduced speeds are reached the air brakes automatically cut in, and in emergency, magnetic track brakes are used. This type of brake is a natural result of increased speeds as it is independent of wheel-rail friction. When applied, an electromagnet drops to the rail and grips the rail with magnetic force which increases as more braking force is required.

The truck and frame construction is thouroughly in accord with modern developments. Extensive use is made of rubber for springing and quieting and is subjected to shear, thereby preserving its life. Interier appointments make use of Masonite Presdwood, Agasote, Oregon fir,

Mastipave, aluminum, chromium, Corten, stainless steel and rubber. Houdaille shock absorbers are installed on the right side of the rear truck bolster and on the left side of the front truck bolster to prevent synchronized oscillations. Roller bearings are used instead of sleeve bearings and the journal boxes are mounted on pivoted pins fastened to the side frames, thus doing away with the pedestals and guides. The wheels are resilient and axles of hammered steel. The motors (4) are high speed, spring supported, rated at 50 HP and drive through a double reduction gearing at a ratio of 7.55 to 1.

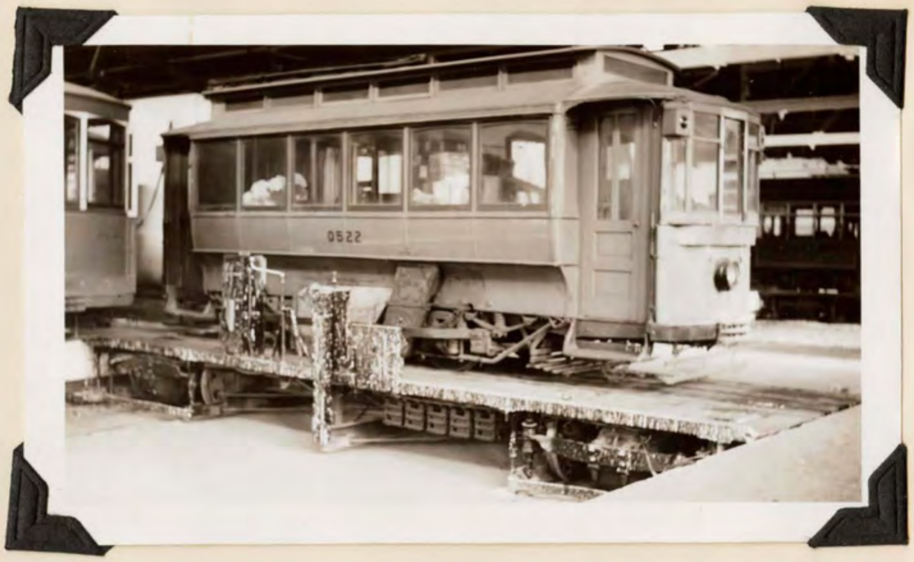
The length is 44 feet, the weight 35,000#. They are ventilated through a forced exaust capable of 1000 cubic feet/minute, and are heated by 14 panel type heaters located at the side of the car at the floor line.

FUTURE

Considerable criticism has arisen due to the obsolescense of the majority of street cars now operating. In meeting this criticism the Capital Transit Co. has decided to scrap all its open cars and 200 more of the worst ones. Also, there has already been ordered 47 more streamlined cars and contemplation of 200 new ones.

The trend is toward lighter, speedier cars brought about by light weight alloys and better technique of construction. Four gas-electric vehicles have been ordered and are going to be tried out. This type has been occasioned by the growing demand for smoother, quieter service , which is now ushering in a new era in street transportation. It is believed that with the advent of new equipment and complete modernization, the street cars will regain much of the ground that they lost to the buses during their hybernation.

V.G.



Old 1900 single truck car converted into a rail grinder car

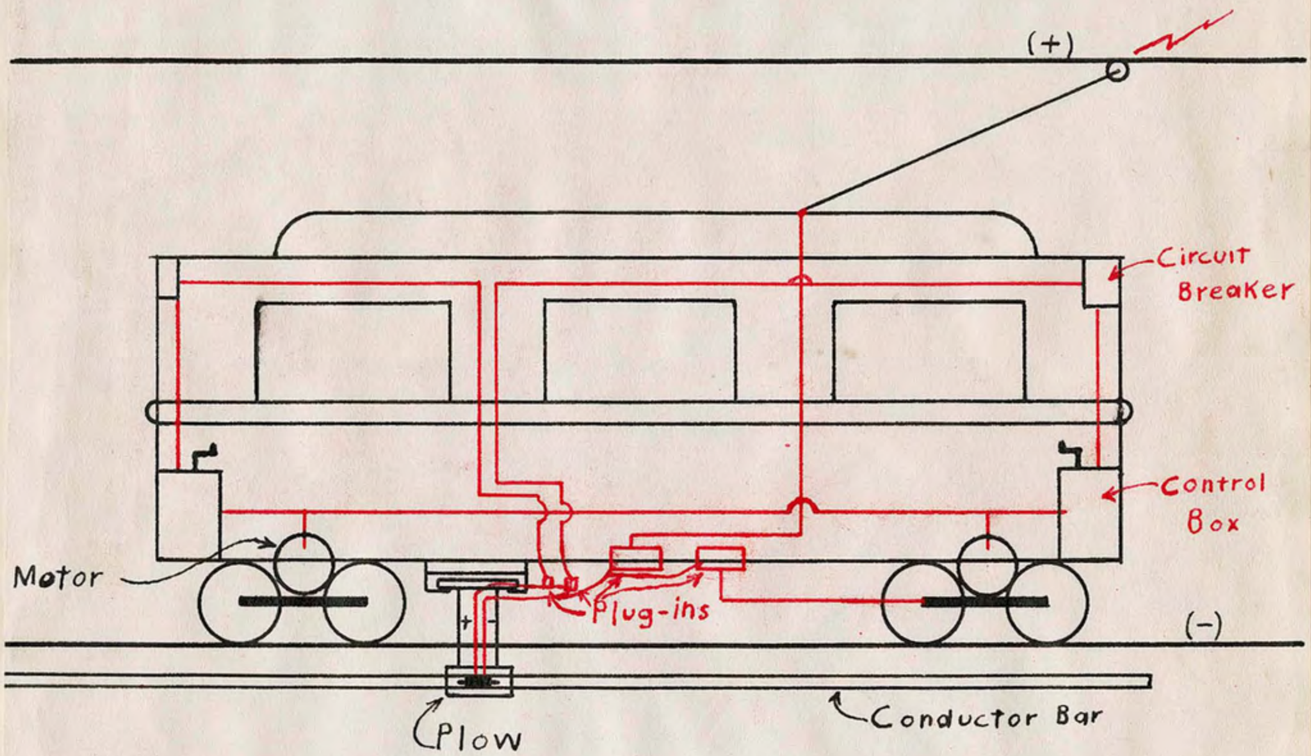
(carbarn, 14'th and East Capital)

Scrapping of the last open cars

1915 type--representing the bulk of Washington's 700 street cars


Streamlined car-1936 model

General offices of Capital Transit Co.- 38'th and M Streets, N. W.




TYPICAL CAR WIRING

BIBLIOGRAPHY

"Transit Journal"-September 15, 1934

1931 Appraisal Washington Railway and Electric Co.--W. B. Bennett, valuation engineer

1931 Appraisal Capital Traction Co.

"Transit Journal"-March, 1935

"Beginnings o f Street Railways in the National Capital"- -Dr. William Tindall-February 20, 1917

"Transit Journal"-June, 1935

Washington Daily News

Capital Transit Co. street car publications

Reports of Congressional Committees 1906-1932